THE BACTERIOLOGY OF PYELONEPHRITIS.[1]

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IN considering the etiology of nephritis a broad distinction must be made between those forms known under the general name of Bright's disease and pyelonephritis, or the so-called surgical kidney. In the first-mentioned forms, which may be denominated hæmatogenous, the primary cause of the renal inflammation is, as a rule, and perhaps always, some toxic substance in the blood which acts as an irritant to some portion of the renal parenchyma. And when micro-organisms are found in the urine in cases of this kind or in sections of the kidney removed post-mortem, their presence is probably to be regarded either as accidental or as secondary to the changes in the kidney, rather than a cause of these changes. It is not at all unusual to find colonies of micrococci or of bacilli in the necrotic foci found in certain forms of nephritis, but the inference that the inflammatory process and resulting necrosis were due to these bacteria is not justified either by the microscopic appearances of the sections or by experimental investigations. On the other hand, in ascending nephritis or pyelonephritis, which is very commonly secondary to a cystitis of long standing, there is good reason to believe that the inflammatory changes and pus formation depend principally upon the presence of certain bacteria which are found in the urine of such patients during life and in the diseased kidney removed by surgical operation or post-mortem. And recent researches show that the bacillus coli communis, which is constantly present in the intestine of healthy individuals, is found more frequently than any other micro-organism in the so-called "surgical kidney." This bacillus is now known to be the usual cause of peritonitis. It has been obtained, in pure culture, from a number of cases (8) of abscess of the liver,[2] from urinary abscesses (6),[3] and from the pleural cavity in certain cases of pleurisy (9).[4]

The most important and comprehensive work upon the bacteriology of pyelonephritis is that of Schmidt and Aschoff,[5] published in Jena in 1893. The authors named give a complete *résumé* of the literature of the subject, and a full report of fourteen cases of pyelonephritis, in which they have made bacteriological investigations. They also report a series of experiments upon rabbits, in which injections of a pure culture of the bacillus coli communis were made into the left ureter, after tying it below the point of injection. The ligature was removed after the injection had been made and the wound in the abdominal wall, which had been made with antiseptic precautions, was closed. Some of the animals so treated died in from twelve hours to four or five days, while others survived and were killed on the seventh and ninth day.

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[1] Read before the Congress of American Physicians and Surgeons, Washington, May 31, 1894.

[2] Bignami, Stern, Netter and Martha, Rodet and Roux, Létienne, Veillon and Jayle, Vivaldi, Levy.

[3] Krozius, Clado, Albarran and Hallé, Tuffier and Albarran.

[4] Albarran and Hallé, Sevestre, Renard, Lesage and Macaigne, Levy.

[5] Die Pyelonephritis in anatomischer und bacteriologischer Beziehung, und die ursächliche Bedeutung des Bacterium coli commune für die Erkrankung des Harnwege.

The left kidney, especially in the cases which survived the operation for several days, was found to be two or three times as large as the right and to present all the evidences of parenchymatous inflammation. The pelvis of the kidney contained more or less ammoniacal urine, pus, and bacilli; the parenchyma gave evidence of diffuse inflammation and contained numerous bacilli. As a rule a pure culture of the bacillus coli communis was obtained from the inflamed kidney.

A similar experiment was made with a species of proteus (vulgaris?), and with a similar result. The animal died at the end of two days. The left kidney was twice as large as the right, the surface of a deep-red color dotted with numerous white spots; the parenchyma had a striped appearance on section and a greenish color in the vicinity of the pelvis, which contained ammoniacal and bloody urine. A putrefactive odor was given off from the organ. Proteus in pure culture was recovered from the interior of the kidney.

Another rabbit received in the same way an injection into the ureter of a bouillon culture of staphylococcus pyogenes aureus. The animal died at the end of forty-eight hours. A fibrinous inflammation was found at the point of injection and the left kidney was about twice as large as the right. The capsule was easily detached and the surface was of a deep-red color dotted with small white foci of infection, which also existed throughout the organ. The pelvis contained thick reddish-colored pus. Staphylococcus aureus was recovered in cultures from the kidney and from blood taken from the heart.

Schmidt and Aschoff say that the changes found in the kidneys of rabbits after the injection of bacillus coli communis into the ligated ureter correspond with those seen in the "surgical kidney" of man. They were surprised at the rapidity with which the bacilli penetrated the urinary tubules. The first changes in the parenchyma of the organ occurred at the end of thirty-six hours, and at the end of five to seven days these changes had reached their extreme development. They evidently depended upon the invasion of the urinary tubules by bacilli. This conclusion corresponds with that reached in previous researches by Albarran,[1] Achard and Renault,[2] and by Krogius.[3] According to

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[1] Thèse de Paris, 1889.

[2] Sur les rapports du b. coli comm. avec les b. des infections urinaires. Soc. de Biol., 1891, p. 830.

[3] Recherches bactériologiques sur l'infection urinaires. Helsingfors, 1892.

Schmidt and Aschoff, some of the earlier observers have described non-liquefying bacteria obtained from the bladder in cases of chronic cystitis or of pyelonephritis following cystitis, which correspond in morphological and biological characters with bacillus coli communis, and were no doubt identical with it. They believe that the bacillus described by Clado[1] (1887) under the name of "Bactérie septique," and subsequently found by Albarran and Hallé[2] in forty-seven out of fifty cases of cystitis (fifteen times in pure culture), and called by them "Bacille pyogène," is in fact the bacillus coli communis.

The elaborate researches of Rovsing[3] upon the bacteriology of chronic cystitis were published in 1890. Thirty cases were studied, with the following results: In one case diagnosticated as cystitis no bacteria were found; in three cases culture experiments gave a negative result, but the tubercle bacillus was found in the urine by microscopical examination—in these cases the urine was strongly acid; in twenty-six cases the urine was ammoniacal, and in all of these bacteria were found—usually but a single species. All of these grew in the usual culture media except the tubercle bacillus, which in two cases was associated with some other species, and all produced alkaline fermentation in sterile urine when added to it in pure cultures. The following species were found: Tubercle bacillus, staphylococcus pyogenes aureus, staphylococcus pyogenes albus, staphylococcus pyogenes citreus, streptococcus pyogenes ureæ (n. sp.), diplococcus pyogenes ureæ (n. sp.), cocobacillus pyogenes ureæ (n. sp.), micrococcus pyogenes ureæ flavus (n. sp.), diplococcus ureæ trifoliatus (n. sp.), streptococcus ureæ rugosus (n. sp.), diplococcus ureæ (n. sp.), cocobacteria ureæ (n. sp.).

Pure cultures of all of these species introduced into the bladder of rabbits failed to induce cystitis, even when injected in considerable quantities. But when retention of urine was effected artificially for six to twelve hours, allowing time for ammoniacal fermentation to occur, cystitis was developed. When the pyogenic species were introduced under these circumstances, a suppurative inflammation of the mucous membrane occurred; the non-pyogenic species caused a catarrhal cystitis. Rovsing records the important fact, as bearing upon the etiology of cystitis, that in twenty of the cases examined the bladder had been invaded by the finger or by instruments prior to the development of cystitis.

Lundstrom (1890) isolated from alkaline urine obtained from patients with cystitis two species of staphylococci—staphylococcus ureæ candidus and staphylococcus ureæ liquefaciens; from albuminous, acid urine he obtained streptococcus pyogenes.[1] Krogius obtained from the urine of individuals suffering from cystitis a bacillus which he calls urobacillus liquefaciens septicus. Schnitzler[2] (1890) found the same bacillus, or one very similar to it, in thirteen out of twenty cases of purulent cystitis examined by him. In eight of these cases it was obtained from the urine in pure cultures, and in five it was associated with other bacteria. In twelve of these twenty cases the cystitis resulted directly from catheterization; in the others it occurred in individuals suffering from stricture or from calculus.

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[1] Deux nouveaux bacilles isolés dans les urines pathologiques. Soc. Anat., May, 1887, p. 339.

[2] Note sur une bactérie pyogène et sur son rôle dans l'infection urinaire. Bull. de l'Acad. de Méd., T. xx., 3e S., Paris, 1888, p. 310.

[3] Die Blasenentzündungen, etc. Berlin, 1890.

When cultures of this bacillus were injected into a vein in rabbits, the animals died in from three to eight days, and in every instance an intense nephritis was observed at the autopsy—twice with the formation of small abscesses. The bacillus was found in the blood and the organs generally. Injections into the bladder of rabbits almost always gave rise to a severe purulent cystitis—large rabbits were selected, and great care taken not to injure the mucous membrane of the bladder. Schnitzler was not able to induce cystitis in rabbits by injecting in the same way considerable quantities of a culture of staphylococcus pyogenes aureus.

According to Schmidt and Aschoff subsequent researches indicate that some of the species described by Rovsing as being new are in fact varieties of bacillus coli communis.

The identification of the bacillus pyogenes of Albarran and Hallé (Bactérie septique of Clado) with bacillus coli communis was first made by Krogius[3] (1891), and about the same time by Achard and Renault.[4]

In twelve cases of cystitis, six of which were complicated with ascending nephritis, Krogius demonstrated the presence of bacillus coli communis, and showed that in its growth in culture media it corresponded with the bacillus pyogenes of previous authors. In a second communication Krogius[5] states that in twenty-two cases of cystitis studied by him he obtained bacillus coli communis sixteen times, and of these fourteen times in pure culture. He also calls attention to the fact that in those cases where no other micro-organism was associated with the colon bacillus the urine was always acid—a statement which is sustained by the subsequent researches of Schmidt and Aschoff. He also gives details with reference to the pleomorphism of this bacillus and differences in the appearance of gelatin cultures from different sources, the growth being sometimes opaque and sometimes transparent. When cultures of this bacillus were injected into the bladder of rabbits and retained by ligating the urethra, an intense cystitis was developed in from twenty to thirty hours. Injections into the ureter gave a result similar to that subsequently reported by Schmidt and Aschoff. The animal died in about two days, and pyelitis, together with more or less necrosis of the renal epithelium, was found at the autopsy. Reblaub[1] (1892) obtained bacillus coli communis in pure culture in six out of sixteen cases of cystitis examined.

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[1] Sur un bacille pathogène trouvé dans les urines pathologiques. La Semaine Méd., 1890, No. 31.

[2] Zur Aetiologie der akuten Cystitis. Centralbl. für Bakteriol., Bd. viii., 1890, p. 783.

[3] Note sur le rôle du b. coli commune dans l'infection urinaire. Archiv de Méd. expér., t. iv., 1892, p. 66.

[4] Sur les rapports du b. coli commune avec le b. pyogènes des infections urinaires. Soc. de Biol., Dec. 12, 1891, p. 830.

[5] Recherches bactériologiques sur l'infection urinaire. Helsingfors, 1892.

In their latest publication Achard and Renault[2] arrive at the conclusion that there are some differences between their "urobacillus" and bacillus coli communis, which they state as follows:

1. Upon most media, especially upon malt-agar, the growth is more luxuriant.
2. Cultures of the urobacillus upon potato appear grayish-white, very luxuriant, and have many gas-bubbles.
3. The urobacillus develops much gas even in gelatine and agar cultures containing little sugar.

Morelle[3] (1872) and Denys[4] (1892) in their bacteriological researches obtained from numerous cases of cystitis a bacillus which they identified with bacillus lactis aërogenes of Escherich. But the last-mentioned author has since stated that this bacillus presents varieties which cannot be distinguished from the typical cultures of bacillus coli communis.

The recent researches referred to having shown that bacillus coli communis is very commonly present in the urine in cases of cystitis, and often in pure cultures, its etiological relation to the disease in question seems probable, and this view is further sustained by experiments upon animals and by the demonstrated fact that retention of urine *per se* does not give rise to inflammation of the bladder. But this is not the only micro-organism which is capable of causing a cystitis when introduced into a bladder which has suffered some kind of mechanical injury or has been subjected to the action of chemical irritants contained in the urine. The researches of Krogius, Schnitzler, and of Schmidt and Aschoff show that next to the colon bacillus the micro-organisms most commonly found in cases of cystitis and of pyelonephritis is a proteus (P. vulgaris?).

At the date of the publication of the monograph of Schmidt and Aschoff the bacillus coli communis had been found in pure culture in sixty cases of cystitis, and the proteus in thirteen cases. The authors named say:

"But two species of bacteria (bacillus coli communis and proteus) have, up to the present time, been demonstrated to be the cause of pyelonephritis. When, in addition to these, other bacteria or cocci are found, we have a pyæmic mixed infection."

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[1] Des cystitis non-tuberculeuses chez la femme. Paris, 1892.

[2] Sur les bacilles de l'infection urinaire. Compt. rend. de la Soc. de Biol., April 9, 1892, p. 311.

[3] Étude bactériologique sur les cystitis. Lierre, 1892.

[4] Étude sur les infections urinaires. Bull. de l'Acad. Royale de Méd., Louvain, 1892.

An important point to be kept in view is the fact that when bacillus coli communis is found in the urine in pure culture, this fluid is more or less acid, as the bacillus in question does not give rise to alkaline fermentation, at least not under the conditions found in the bladder and in the absence of retention. But when proteus is present the urine is almost always ammoniacal.

The number of cases of pyelonephritis reported since 1889 by the authors heretofore referred to (Albarran, Rodet, Morelle, Krogius, Achard and Renault, Schnitzler) in which bacillus coli communis was found and was probably the exciting cause of the ascending nephritis, is twenty-nine, and in twenty of these the bacillus referred to was found in pure culture.

Finally, I think we are justified in concluding that cystitis and ascending pyelonephritis are usually caused by micro-organisms introduced through the urethra into a bladder which is rendered susceptible to infection by mechanical violence or chemical irritation. And that the most frequent cause of such local infection is the bacillus coli communis, which is constantly present in the intestine and upon the external surface in the vicinity of the anus, from whence it may easily be transported to the interior of the bladder by catheters, etc., used by the patients themselves or by their medical attendants. According to Bouchard[1] it has been shown that this bacillus is sometimes found under the prepuce and about the vulva of healthy persons, and this is what we should expect from their proximity to surfaces which are constantly soiled with discharges containing it. But there is no evidence that the bladder is reached by the direct invasion of this or other bacteria without mechanical assistance. The researches of Lustgarten and of Mannaberg[2], and of Krogius[3] show that bacillus coli communis is not found in the normal urethra.

THE ABUSE OF TRACHELORRHAPHY.[4]

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The question of the immediate closure of torn cervices I will not discuss in this paper, but will deal only with the operation as applied to conditions which have existed for some time.

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[1] Charrin: Sur la bactérie commune des infections urinaires. Soc. de Biol., 1891, p. 851.

[2] Ueber die Mikro-organismen der normalen männlichen Urethra. Vierteljahrsschr. f. Dermatol. u. Syph., 1887, No. 4.

[3] Arch. de Méd. expér., 1892, p. 75.

[4] Read before the American Gynecological Society, Washington, D. C., May 29, 1894.